

A neutral atom quantum register

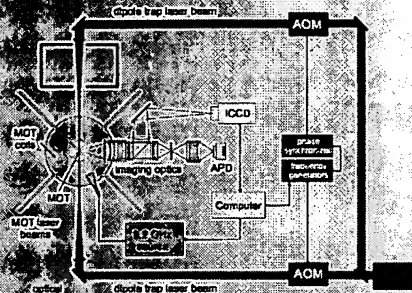
W. Alt, I. Dotsenko, M. Khudaverdyan, D. Meschede,
Y. Miroshnichenko, A. Rauschenbeutel and D. Schrader

Abstract

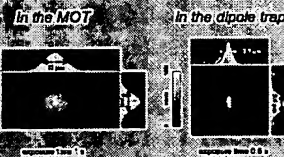
We demonstrate the use of a string of Cesium atoms trapped in our standing wave dipole trap [1] as a quantum register. We have initialized, selectively addressed, coherently manipulated and state selectively detected the hyperfine states of individual atoms within the string using microwave radiation and resonant laser pulses [2]. To spectroscopically distinguish atoms we apply a magnetic field gradient which produces a position-dependent (Zeeman) shift of the atomic transitions. Using a CCD camera we spatially resolve individual atoms within the trap [3] and get information about their exact positions [4]. The population of each individual atom can coherently be transferred by applying microwave radiation at the corresponding resonance frequency of the atom. The population of a neighbouring atom is not affected if its distance to the addressed atom is larger than $2 \mu\text{m}$. The coherence properties of the atoms are characterized by observing Rabi oscillations on single atoms which show no contrast decay within the measurement time of 200 μs . Using the standard spin-echo technique the irreversible dephasing time T_2^* was determined to be 600 μs . The absolute position of a trapped atom can be determined with a precision of 130 nm within 1.5 μs . Furthermore, it is actively controlled by means of our optical conveyor belt, which allows us to transport the atom to a chosen position along the trap axis over a millimeter scale distance [1, 5]. The accuracy of the position control is 300 nm and is limited by technical, rather than fundamental reasons [4]. The absolute position control is an important prerequisite for e.g. introducing atoms into an optical resonator, which will enable controlled coherent interaction between two or more atoms.

- [1] D. Schrader et al., Appl. Phys. B 73, 819 (2001)
- [2] D. Schrader et al., submitted to PRL
- [3] Y. Miroshnichenko et al., Optics Express 11:3498 (2003)
- [4] I. Dotsenko et al., in preparation
- [5] S. Kuhn et al., Science 293, 276 (2001)

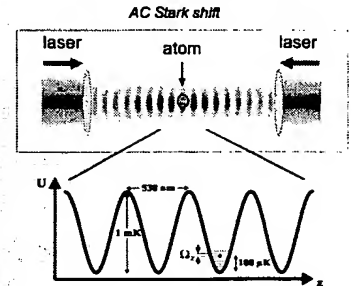
Experimental setup



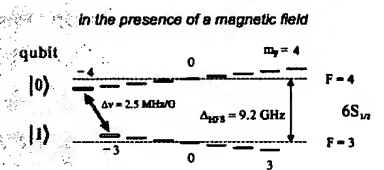
Imaging a single atom



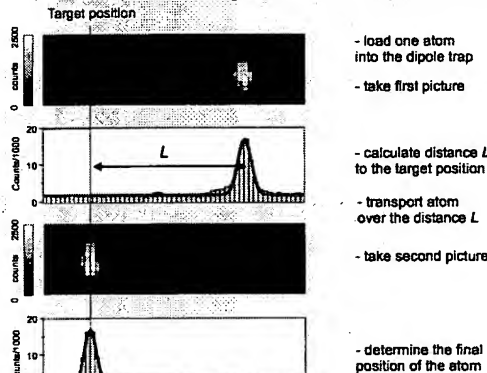
Atom in the dipole trap



Cesium ground state

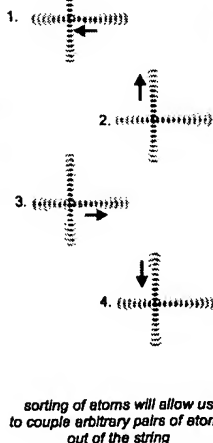


Absolute position control



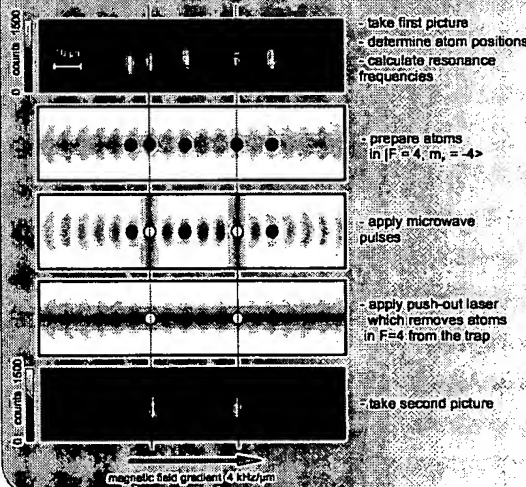
Outlook

Relative position control:
sorting of atoms using
a perpendicular DT



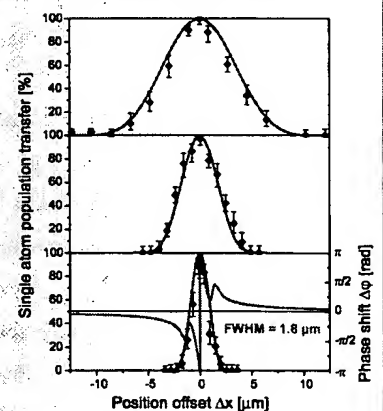
Addressing of individual qubits of the register

Experimental sequence



Spatial resolution

experimental results
and theoretical simulations

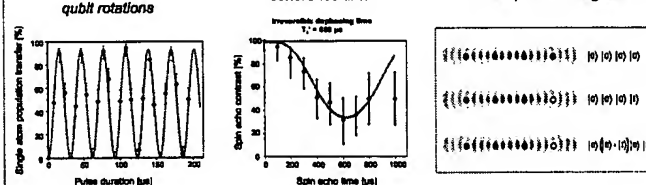


Quantum information in the register

Rabi oscillations
on single atoms

Spin echo measurements

Information stored
in the quantum register



Outlook

Placing atoms into
a high-Q optical resonator
controlled interaction
between atoms via
cavity photon exchange

